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A conceptual and methematical model was developed to study the preparation of persons holding Bachelor's, Master's and Doctoral degrees and to discover the proportion of them who assume academic positions. Data were collected on the number of US and foreign engineering students enrolled, degrees granted, and their employment in academic, industrial, governmental and other sectors of the national economy. The model, consisting of over 200 non-linear difference equations, was programmed for computer simulation and validation against data collected. It broke down the academic sector into undergraduate, master's, doctoral and post-doctoral programs; each of the other sectors were broken down according to the highest degree held by their employees. Project objectives included a study of the dynamics of employment in higher education, interrelationships of academically trained manpower with the rest of the economy, the usefulness of available data, the impact of inflow and outflow of foreign nationals on US economy, and the impact of development in educational technology upon the manpower redistributions in the economy. The overall aim was to determine future manpower needs and set national standards for higher education in order to meet those needs. Software problems which developed with the Burroughs B500 computer installation were not resolved and the simulation results were inconclusive. A supplementary final report will be submitted upon completion of current work. (WM)

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"FLOW OF DOCTORATE HOLDERS INTO COLLEGE AND UNIVERSITY STAFFS: A COMPUTERIZED STUDY"

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U.S. DEPARTMENT OF
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TABLE OF CONTENTS

	Page
SUMMARY	1
INTRODUCTION	2
OBJECTIVES OF THIS STUDY	2
RESULTS	6
METHOD: MODEL DEVELOPMENT	6
SUGGESTED FUTURE EXTENSIONS OF THE MODEL	18
REFERENCES	22
APPENDIX	23

LIST OF TABLES

Table

1. FLOWRATES AND THE MAJOR INFLUENTIAL FACTORS 12

LIST OF FIGURES

Figure

1. THE LOCATIONS & FLOW PATHS OF PEOPLE WITH AN ENGINEERING EDUCATION: A SYSTEMS SCHEMATIC . . . 8

2. THE LOCATION & FLOW PATHS OF PEOPLE WITHIN THE UNDERGRADUATE SUBSECTOR AND THE INTERRELATION OF SOCIO-ECONOMIC FACTORS WHICH "CONTROL" THE POPULATION FLOWS 13

3. A TYPICAL SOCIO-ECONOMIC LOOP 14

4. THE LOCATION & FLOW PATHS OF PEOPLE WITHIN THE POST BACCALAUREATE SUBSECTOR AND THE INTERRELATION OF SOCIO-ECONOMIC FACTORS WHICH "CONTROL" THE POPULATION FLOWS 19

5. THE LOCATION & FLOW PATHS OF PEOPLE WITHIN THE POST MASTERS SUBSECTOR AND THE INTERRELATION OF SOCIO-ECONOMIC FACTORS WHICH "CONTROL" THE POPULATION FLOWS 20

6. THE LOCATION & FLOW PATHS OF PEOPLE WITHIN THE POST DOCTORATE SUBSECTOR AND THE INTERRELATION OF SOCIO-ECONOMIC FACTORS WHICH "CONTROL" THE POPULATION FLOWS 21

SUMMARY

The dynamic effects of alternative manpower policies and programs can be "pretested" in a computer based simulation. It is generally recognized that the production of Doctorates depends to a large degree on the Doctorate-holding faculty. Because the doctorate holders are in great demand by the other sectors of the economy, a circular or a "feedback" situation exists. The problem is further complicated by the availability of developed student talent and by various socioeconomic conditions existing at different periods of time within two or three decades to the time a study is made.

This study developed a conceptual and a mathematical model to study the production of Doctorates, Masters and Baccalaureate degrees and their feedback into higher education. The model consisting of over 200 non-linear difference equations was programmed for computer simulation and validation against historical data. Simulation attempts to describe what has happened in the past have thus far proven inconclusive. However, these failures are attributable to software problems encountered with the University of Wisconsin Burroughs B5500 computer installation. Currently efforts are under way to resolve these problems and the study is continuing albeit unsupported. Once the above phase is accomplished, the model can be used to prescribe what will happen in the future with a fair level of confidence.

INTRODUCTION

The output of higher education in general, and of the professional schools in particular, has been a subject of concern to various agencies of government, of foundations; both public and private, and to the professional associations involved for over half of a century. Data regarding the number of students enrolled and degrees granted have been diligently collected, compiled, classified and reported. On the other hand, data regarding the utilization of the graduates in academic positions, industry, government, etc., are much more sparse, although available. Data regarding the retention within our economy of foreign nationals who have successfully completed their schooling here is more sparse yet, or more precisely unavailable, even though foreign nationals comprise a large segment of the student body in our professional and/or postgraduate programs of study. It is in this setting that planners are attempting to set national policy concerning higher and/or professional education in order to satisfy anticipated or perceived needs for trained talent in the years ahead.

Objectives of this Study

The objectives of this study are:

(1) To develop a simulation vehicle to pretest alternative manpower policies and programs.

(2) To study the dynamics of the higher education sector within our society.

(3) To study the dynamic interrelationship of the various subsectors of higher education in the rest of the economy.

(4) To study the usefulness of currently available data and to indicate what additional data would be useful in determining long-range policy and planning.

(5) To determine the impact on our economy in general (and the higher education sector in particular), of the inflow and outflow of people from other nations.

(6) To study the possible impact of development in the technology of education upon manpower redistributions in the economy and the timing of same (i.e., increases in student-faculty ratios).

During the last two decades attention has been turned to the production and retention, within the higher educational sector of the economy, of people holding the doctorate degree. It is generally recognized that the production of doctorates depends to a large degree on the doctorate-holding faculty. Because the doctorate holders, especially in the sciences, are in great demand by the other sectors of the economy, a circular or a "feed-back" situation exists. The problem is further complicated by the availability of developed student talent and by various socio-economic conditions existing at different periods of time within two or three decades prior to the time a study is made. Various studies of these problems have been initiated by agencies of government and by privately financed foundations.

In order to attempt to rectify an existing situation or provide for future needs, initiators of programs are in need of a rational methodology to evaluate the effects of their programs. Historical data and judgment have not always yielded satisfying bases for decisions. Both the military and industry are recognizing, to an increasing degree, the need for quick and economical ways of evaluating the various effects of their decisions. For this they have turned to analytical methods. Computer-based simulation is one method successfully used to study the dynamics of complex and non-linear problems.

Bolt, Koltun and Levine (1) made the first attempt, in 1965, to model and to study the dynamics of the problem at hand. Their work was indeed landmark in nature, for it showed the advantages of dynamic over statistical analysis of manpower problems while recognizing that the two are not mutually exclusive. The above model conceptually split the economy into two sectors, one sector containing the entire educational establishment (Higher Education) and the other the rest of the economy. The flows of graduates between these two sectors were established recognizing the fact that Ph.D. holders do return to the academic sector to take up faculty or administrative positions while others leave for industry, government, etc. All of the flows including the so-called "feedback" flows were described by two linear difference equations which were simultaneously solved at various values of the equations' parameters.

This highly aggregated approach was considered unjustifiable by this investigator, in view of the inherent complexity of the problem studied and, in light of modern computer capability to solve large sets of differential or difference equations. Consequently, a less aggregated model was proposed (2).

This model broke the educational sector up into four segments; undergraduate programs, master's programs, doctoral programs, and post-doctoral programs. It broke the other sectors of society employing college or university-trained people into segments according to the highest degree earned by those within the segment. Furthermore, it showed the retirement and other attrition sectors more or less as a sink outside of either of the above two sectors. The model delineated the various possible paths for population shifts between the segments.

In a manner similar to (1), (3) and (4) and to many works in the physical sciences, it accounted for all the net flows to a segment and the rate of accumulation of people within the segment.

The equations recognized the fact that degrees, especially at the doctorate level, are not earned at a given time of the year throughout society. Some schools operate on the semester basis, others operate on a trimester, and yet others on the quarter system. When aggregated, an assumption of continuity in flows seemed a little more realistic than an assumption of discreteness. Thus, the equations offered were differential equations. Depending on the postulates regarding lead-lag relationships in the production of the various degrees these equations were allowed to be non-linear.

The basic advantages of that model over (1) were described in outline as follows:

1) It recognized the input of students into the higher education sector.

2) In the educational sector, it distinguished between persons who have recently become engaged in the educational function and persons who have worked in education for many years.

3) It recognized that the relationships between the variables involved were not necessarily linear in nature.

4) It distinguished between the use of doctorate holders in education at the doctorate, master's and undergraduate levels.

5) It considered the effect of the rates of production of high school, bachelor and master's graduates in successively preceding years.

6) It considered post-doctoral university programs and the interrelated flows from them to teaching at the various levels and to the other sectors employing doctorates.

7) In as much as the rate of doctorate production has changed drastically during the last three decades, because of the depression of the 1930's, World War II, and the post-war and the cold-war periods, it emphasized that the age mix is not a uniform one. Thus, the number of degrees granted some years prior (say 30 or 35 years) is the independent variable used in calculating attrition in that model.

8) Concern for economic, social, and physical influences in doctorate production and shifts in employment was accomodated.

A tangible result of this study was the rearrangement, extension and modification of the above model. This latter version of the model described in the following section and spelled out in detail in the Appendix to this report was discussed and reviewed with colleagues in various settings. The first presentation took place at the 14th International Meeting of the Institute of Management Sciences which was held in Mexico City, August 22-25, 1967. (6) The next presentation took place at the "Operations Analysis in Education" Symposium sponsored by the Office of Education and held in Washington, D.C., November 19-22, 1967. The Fall issue of the Journal, Socio Economic Planning Sciences, which is devoted to the Proceedings of that conference, will carry the paper "On the Generation of Doctorates and Their Feedback into Higher Education". A presentation of this model was also made at the "Engineering Manpower Planning Institute", which was held in Madison, Wisconsin, January 8, 9, 1968. At all of these meetings this model generated quite a bit of active discussion resulting in several additional changes of the model.

Unlike its predecessor, this model separates out the student and the faculty subsectors within the academic sector and does this at all levels of educational attainment. It provides for inflows as well as outflows of foreign nationals at various levels of attainment.[1] This model explicitly provides for the psychological, sociological and economic factors which influence the movement of personnel from one sector to another within our economy. It furthermore is expressed in terms of "difference" types of equations as opposed to differential equations.[2]

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[1]This extension was suggested by Dr. Lindsey Harmon, Director of Research, Office of Scientific Personnel, National Academy of Sciences National Research Council.

[2]The change from differential to difference equations was necessitated by the availability of the DYNAMO compiler for the B 5500 computer. Although difference equations are used, the time increment considered is relatively short, specifically it is 1 calendar month.

A detailed description of this model is given in Appendix I to this report.

RESULTS

Because of the software problems with the Burroughs B 5500 computer which was the only computer, large enough for the purpose available to us at the University of Wisconsin, this investigator regrets to report that no useful simulation runs are as yet available. Although the project grant has run its course, work is still continuing on the project, albeit at the principal investigator's new location, the Department of Operations Research, Case Western Reserve University, Cleveland, Ohio. Two graduate students are working with the principal investigator on this project. Current work involves the simultaneous programming of this model for solution on either the Univac 1108 computer or the IBM 360-40 machines. It is the investigator's intent to submit a supplementary final report on this work as soon as the simulation has been completed resulting in substantive or new insights to the problem.

METHOD: MODEL DEVELOPMENT

Figure 1 describes all of the sectors and subsectors of our economy and the paths through which population shifts may take place. In moving upward along the diagram we find that the lowest layer in Figure 1 symbolically houses all personnel who are either studying for the Bachelors Degree (subsector S1) or who have dropped out after some university or college training and are in industry (Subsector P1). The non-degree holders layer allows for three types of personnel inflows. Thus, high school students can enter the student subsector via the H1S1 path. Similarly, high school graduates from other nations can enter the same subsector via the flow path labeled E1S1. The model allows for foreign nationals who have had some college or university training but who have not attained the equivalent of a Bachelors Degree to enter the model via the path E1P1. It was a matter of convenience to allow these people to enter only into the professional (P1) subsector. It is fully recognized that many of these people may, in fact, enter the country with the intention of studying further toward a Bachelors Degree and this may, in fact, be the predominant majority of such entrants. It was felt that in due time these people will, in fact, enter the student sector within the model. The availability of data, or better, the lack thereof, justifies this simplifying assumption in the construction of the model. Using similar reasoning, it was felt that all non-achievers who leave the country prior to obtaining their Bachelors Degree will leave via the professional subsector rather than leaving directly from the student subsector. The flow P1E1 allows for all foreign nationals with some

undergraduate education to leave the country. The two remaining flows out of layer number 1 allow for the students who have, in fact, obtained the Bachelors Degree to move out and go on to anyone of the three subsectors in layer 2 which contains all personnel holding a Bachelors Degree.

Before moving into layer 2, however, we must account for all those people who leave layer 1 as the result of retirement or attrition. These are basically people who have completed their useful economic lives either as technicians or supporting personnel and are leaving the productive economy into permanent and complete retirement. The flow which allows for this to take place is P1R1. Layer 1 allows for two intra-layer flows, specifically flow S1P1 which channels all of the students who have dropped out into the professional or productive subsector P1. Similarly, flow P1S1 allows for students who have at one time dropped out to reenter the academic or student subsector S1 in order to continue their studies for the Bachelors Degree. It should be noticed that subsector P1 represents that part of the economy, be it government, industry, commerce, or whatever, which employs people having some college training but no degree.

The interlayer flows can only come, in this model, from the student subsector of the layer below. Thus, all those who have successfully completed their Baccalaureate studies leave subsector S1 in layer 1 and move on to either of the three subsectors in layer 2. Layer 2, representing all those who do hold a Bachelors Degree but no more, differs from layer 1 in that within this layer there are three subsectors. In addition to subsector S2, which represents all students studying for a Masters Degree, and subsector P2 which represents all those holding a Bachelors Degree but not more who are productively employed by our society in all areas other than university or college-level teaching, subsector F2 houses all Bachelors holders who hold no higher degree and who are employed in an academic capacity within higher education.

Layer number 2 allows for only two inflows. Recent graduates with a Bachelors Degree from the layer below and foreign nationals who enter the country holding a Bachelors Degree (E2P2). Again, in this case as in layer 1, the assumption was made that all foreign nationals enter through the professional subsector. Similarly, all foreign nationals who leave this country holding a Bachelors Degree, but no more, leave through the professional subsector of layer 2 (P2). In this case, retirement is allowed both from the professional subsector, namely P2R2 and also from the faculty or academic subsector, namely F2R2. It was felt that the retirment age of academics was generally somewhat different than the retirement age of people from industry or from government. Hence, the two flows were separated.

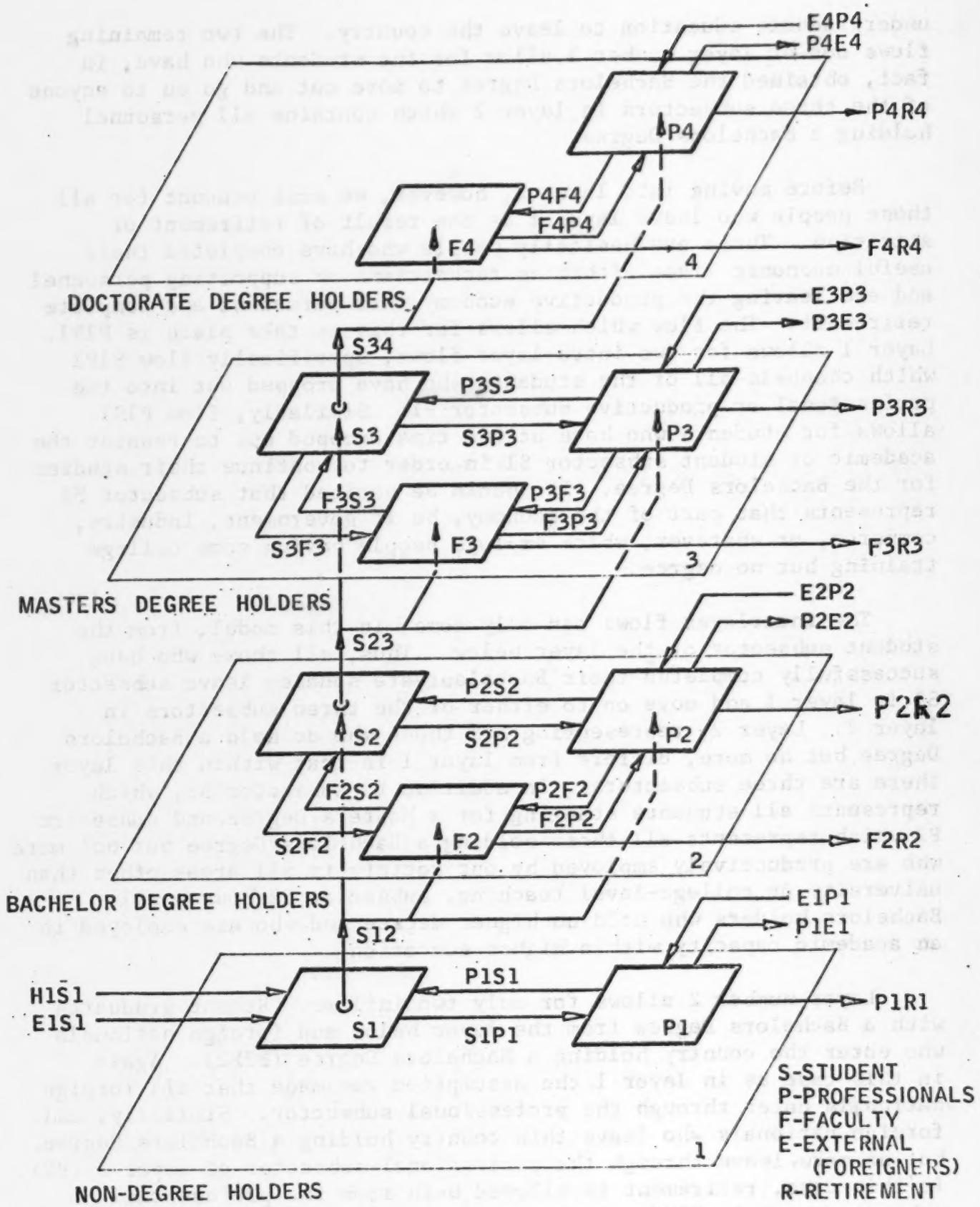


Figure 1

The Locations & Flow Paths of People with an Engineering Education: A Systems Schematic

In layer 2 there are not two but six possible intralayer flows. In addition to the population shifts between the students subsector S2 and the professional subsector P2, there are now similar paths for population shifts between either of these subsectors and the faculty subsector F2. All those who have successfully completed their studies toward a Masters Degree can leave layer 2 and move on to layer 3 via the channel labeled S23. Layer 3 is conceptually similar to layer 2 although within it reside all those who hold a Masters Degree but no higher degrees. From layer 3 individuals may move up to layer 4 upon satisfactory completion of the Doctorate Degree. Layer 4 is different from layers 2 or 3 in that within it reside all Doctorate holders and this layer does not contain a student subsector. Although it is recognized that there are post-doctoral students, it was felt that most of these people do hold an academic rating, and so for the sake of simplicity, the student subsector was eliminated.

It should be noted that except for the exogenous inputs, all of the flows either originate and/or terminate at one of the subsectors. Therefore, at each subsector it is possible to write a "personnel" conservation equation in a manner analogous to the conservation equations of either mass or energy or momentum in the physical sciences. These equations basically take into account, at any instant of time, all of the inflows, outflows and rates of accumulation within a subsector. The equation states that the total rate of flow into a subsector minus the rate of outflow is equal to the rate of accumulation or growth of population within a given subsector. Equation 1 states this in descriptive terms. It should be noted that the rate of generation term, quite often used in the physical sciences, is meaningless in this case and therefore forced to equal zero. What we are basically saying here is that within a given subsector there can be no people generated. Any generation which does take place in our population takes place some time prior to the individual's entrance into either the academic or professional subsectors. Equation 1 is described in mathematical symbols by equation 2.

$$\left[\begin{array}{c}\text{Sum of}\\ \text{Input}\\ \text{Rates}\end{array}\right] - \left[\begin{array}{c}\text{Sum of}\\ \text{Output}\\ \text{Rates}\end{array}\right] + \left[\begin{array}{c}\text{Rate}\\ \text{of}\\ \text{Generation}\end{array}\right]^{0} = \left[\begin{array}{c}\text{Rate}\\ \text{of}\\ \text{Accumulation}\end{array}\right] \qquad (1)$$

$$\sum M_i - \sum M_o = \frac{d}{dt}(M) \qquad (2)$$

Equation 2 may be rearranged from its differential formulation to an integral formulation which is done in equation 3.

$$\int_{t}^{t+dt} [\sum M_i - \sum M_o]dt = \int_{M_t}^{M_{t+dt}} d(M) \qquad (3)$$

If we now force the infinitesimal time increment dt to be equal to Δt a finite increment of time, and similarly, we allow the infinitesimal increment of accumulation dM to be equal to ΔM, then we may transform equation 3 to its difference format with but a few apologies to those who are inclined toward the purity of mathematics.

Let

$$dt \rightarrow \Delta t, \quad \text{and} \quad dM \rightarrow \Delta M$$

$$[\sum M_i - \sum M_o]\Delta t = M_{t+\Delta t} - M_t \qquad (4)$$

Allowing for some additional transformations such as those described by equation 5

$$\text{If} \quad t = J, \quad t + \Delta t = K, \quad \text{And} \quad \Delta t = DT \qquad (5)$$

we can move on to equation 6

$$M_K = M_J + [\sum M_i - \sum M_o]\Delta t \qquad (6)$$

and then on to equation 7

$$M.K = M.J + (DT)\ [\sum M_i - \sum M_o] \qquad (7)$$

which is in a format easily comprehended by the DYNAMO compiler developed in connection with a social-systems simulation methodology generally known as industrial dynamics which was developed by Professor J. W. Forrester at the Massachusetts Institute of Technology.

Although the level equations are determined by a straight forward application of the law of conservation of mass, the rate equations are determined largely by a group of relationships between many diverse factors. A brief summary of the "flowrates and the major influential factors" is given in Table 1. The table shows that the flowrates from one sector to another are determined by such gross influential factors as societal needs, group psychology,

student capabilities, national needs for faculty, student-faculty ratios, inputs, world technological gaps, and so forth. The approach that is used in combining these and determining the flow rate can perhaps be best explained by means of a number of specific examples.

In Figure 2, we see an expanded version of the non-degree holders level where the student sector S1 and the professional sector P1 are shown in the square boxes. Let us consider the flow of professionals from P1 to S1 and call that flowrate P1S1. In order to understand the dynamics of the flowrate P1S1 we resort to a psychological submodel which is given in Figure 3.

There are a number of students studying for a Bachelors Degree in subsector S1. After some length of time which we call a delay (say six months) we observe or count the number of students that exist in that sector. This delay is due to the fact that we do not usually count large number of students instantaneously, but it takes some time before our bookkeeping system presents the data to decision makers. Furthermore, even after the figures regarding head count are available, it takes some additional time for the decision makers to become really aware of what the figures mean. At the same time that there is an observation of the number of students, there exists in society a need for people to obtain a Bachelor's Degree namely, a need for students in the Bachelors program. This need is generated by the discrepancy between the number of students who have a Bachelors Degree and those that we think we need with such a degree. It is reasonable to expect that if there is no difference between the need for students and the number of students that we observe there will be no dissatisfaction with the conditions that prevail. However, if we need more students than we have, there is some dissatisfaction generated. As the dissatisfaction grows there is a pressure to change the number of students that we observe, namely to open the valve P1S1 and let more students into school.

The relationship between dissatisfaction and pressure to change the number of students is not a linear one. It can be seen from Figure 3 that the relationship may be represented by an S-shaped curve. Thus, if there is very little dissatisfaction there is no pressure. But as the dissatisfaction grows, the pressure builds up rapidly. After the dissatisfaction has reached some large value, the pressure does not continue to increase linearly, but levels off and thereafter no matter how great the dissatisfaction, the pressure no longer increases. This kind of a relationship is representative of many real situations which we find in socio-economic situations.

Table 1

FLOWRATES AND THE MAJOR INFLUENTIAL FACTORS

Flowrate	Influential Factors
Professional → Student	Societal Needs Group Psychology
Student → Professional	Societal Needs Student Capability and/or School Standards
Student and Professional → Faculty	Educational System (Student-Faculty Ratio) National Needs for Faculty
Student → Student / Faculty / Professional	Structure of Educational System (Built in Delays) Current Level in Each
(Lower Level) (Higher Level)	Higher Sector Past Inflows and Outflows of Lower Student Sector
Foreign Personnel ⟷ Professional	World Politics (Foreign Relations) Economics World Technological Gap
Professional Faculty → Retirement	Previous Graduation Rates Current Faculty and Professional Levels
Need for Doctorates → Professional	Exogenous Input (Long Range Planning)
High School Graduate → Student	Historical Data (Extrapolated)

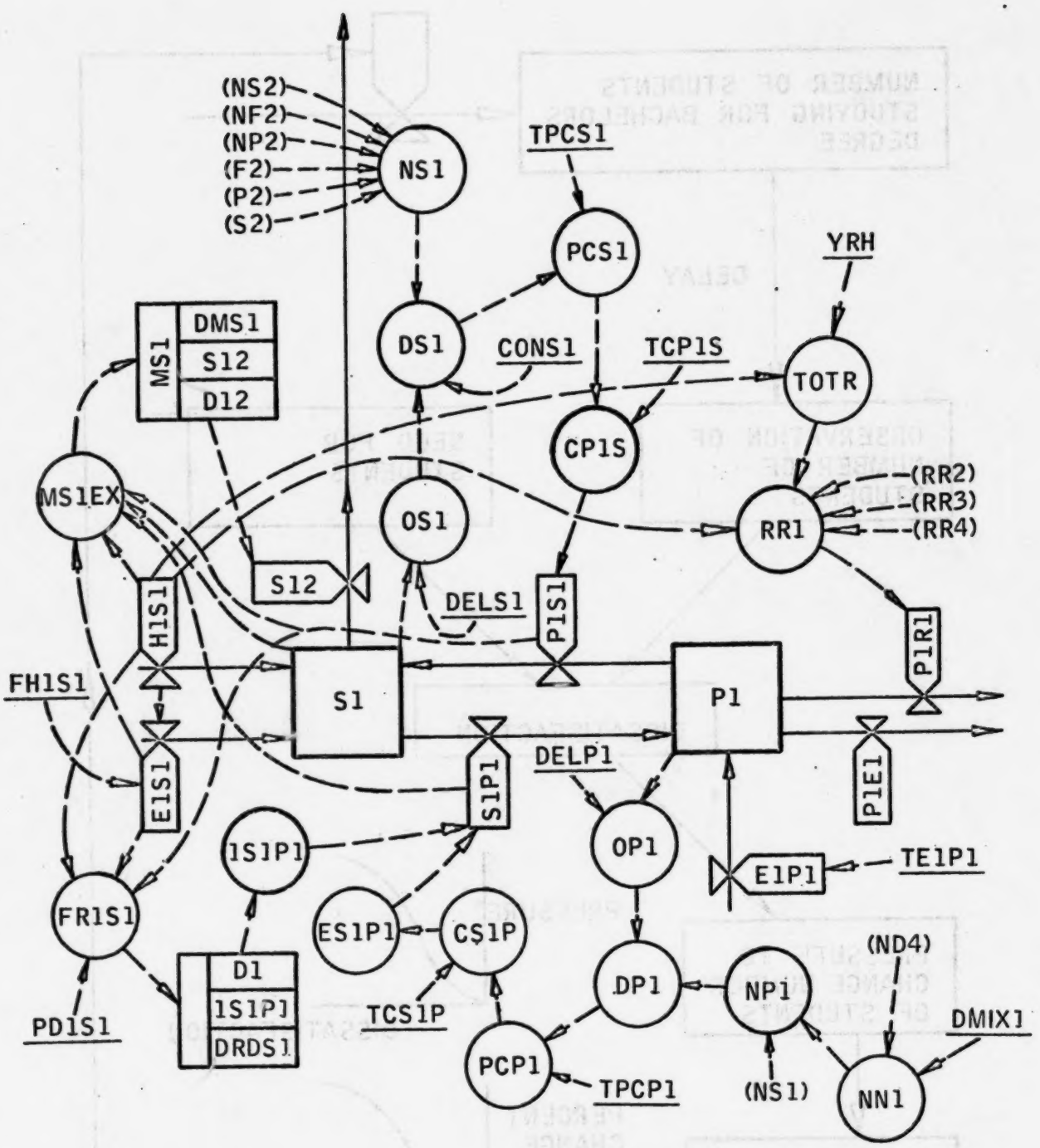


Figure 2

The Location & Flow Paths of People within the Undergraduate Subsector and the Interrelation of Socio-economic Factors which "control" the Population Flows

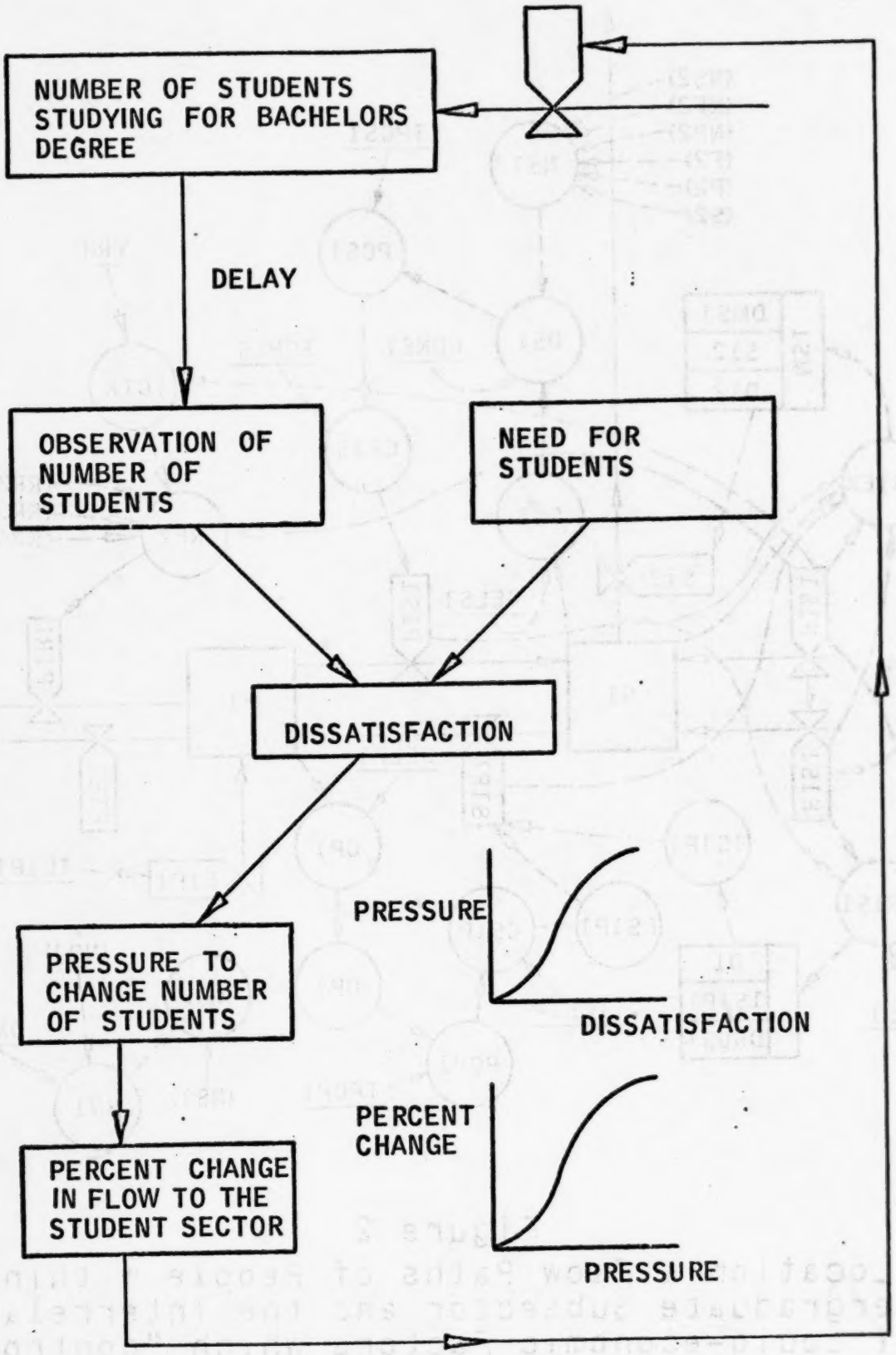


Figure 3
A Typical Socio-economic Loop

In a similar manner, as the pressure increases we tend to make some percentage change in the flow that we allow into the student sector. This means that we might open the valve 2% or 3% greater than it was at the previous instant in time. The relationship between pressure and the percentage of change in the flowrate is similar to the one given for dissatisfaction and pressure. From a mathematical standpoint we could combine the two functions into one composite one, but this would obscure the physical significance of the variables and make it more difficult to make intelligent modifications in the curve. We can see from Figure 3 that the percentage change in flow to the student sector is the variable which will control the flowrate P1S1. Thus we have a dynamic loop in which the feedback, the delays, the need for students and some of the functional relationships that are postulated all combine to regulate the valve.

The actual variables used in this model are shown in Figure 2. OS1 represents the observation of the number of students that exist in the student sector S1 at the present instant of time. This information together with the societal need for students in S1, NS1, yield the variable DS1, which is the dissatisfaction with the number of students in S1. DS1 provides information for generating pressure to change the number of students in S1, namely PCS1, and this in turn provides the information to generate CP1S, which is the percentage change in the flowrate. The change in the flowrate CP1S controls the valve P1S1.

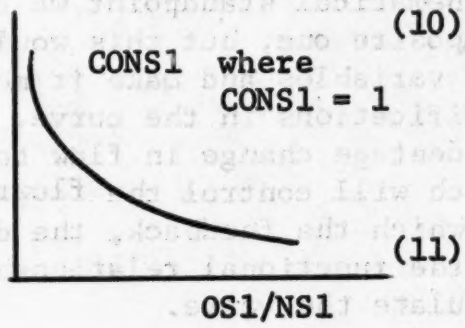
The mathematical relationships which represent the foregoing dynamic loop are represented by equations (8) through (15). With the exception of a number of sumbols peculiar to the dynamo program and our own nomenclature, the equations are self-explanatory. It will be noted that in equation 10, S1D* (11.J) represents a special computer routine which stores the number of students in S1 at a given instant in time and makes that number available sometime later (say 6 months later) in the analysis. In equations (13) and (14), the symbols TPCS1 and TCPS represent tables of values that give the relationship between DS1 and PCS1, as well as PCS1 and CP1S. The tables are shown graphically beside the equations. Finally, the flow rate P1S1.KL which represents the flow rate during the time interval between time K and time L is given by the flow rate between time interval J and K plus some percentage of change in that flowrate. This relationship is shown in equation (15).

$$S1.K = S1.J + (DT)(H1S1.JK + E1S1.JK + P1S1.JK - S1P1.JK - S1P2.JK) \quad (8)$$

P1.K = P1.J + (DT)(E1P1.JK + S1P1.JK - P1S1.JK

- P1E1.JK - P1R1.JK) (9)

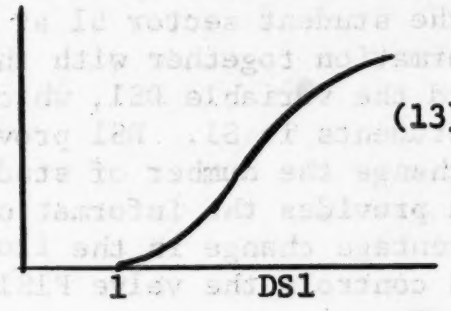
OS1.K = S1D*(11.J) (10)



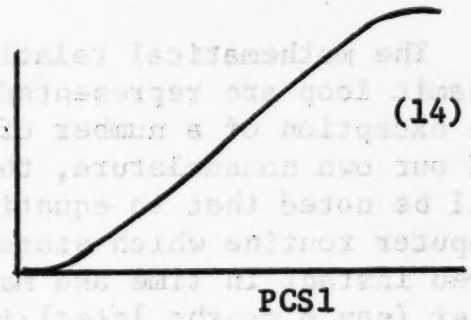
DS1.K = CONS1 / (OS1.J / NS1.J) (11)

NS1.K = NS2.J + NF2.J + NP2.J - (F2.J + P2.J + S2.J) (12)

PCS1.K = TPCS1 (DS1.K) (13)



CP1S.K = TCP1S (PCS1.K) (14)



P1S1.KL = P1S1.JK + CP1S.K (P1S1.JK) (15)

On the other hand, the flowrate from the student sector S1 to the professional sector P1 is controlled by the valve S1P1. The flowrate is determined by some internal as well as external factors. The external factors are similar to those given for the flowrate P1S1 and are controlled by the external needs of our society for professional people NP1. The number of students who dropped out of school and do not achieve a Bachelors Degree is determined not only by the need for professional personnel, but also by the mental ability of the students who enter the Bachelors program and the educational standards of the school. The combination of student abilities and school standards cause some

percentage of the entering students to drop out. The percentage of students that drop out, PD1S1, can be assumed to be a constant or it may vary with time. For the purposes of the initial simulation we will assume that this dropout rate is a constant. The fraction of students that will drop out due to the aforementioned causes, FR1S1, is equal to the percentage of students who entered school from high school from foreign countries and from the professional sector. The students do not drop out all at one time. Most of them drop out during the first year of college and less and less students drop out as the years go by. This phenomenon is taken into account in the model by introducing a special routine known as a delay. The delay routine takes the flowrate and distributes it in an appropriate manner over the time period involved. The flowrate S1P1 is thus the sum of the internal flowrate ES1P1. Some of the definitions of terms and typical equations that are used in the internal loop are given below.

The rate at which students graduate from S1 and who proceed to level 2 is called S12. This flowrate is determined by the rate of students entering as freshman approximately 4 years earlier than the present time minus the rate at which students dropped out over the 4 year period. All of these rates are delayed in an appropriate manner by a delay routine.

PD1S1 = Constant or Variable with Time

= Percent Dropout of Students Entering S1

Due to Mental Abilities, i.e., Internal Reasons

FR1S1.KL = PD1S1 (H1S1.JK + E1S1.JK + P1S1.JK) (16)

IS1P1.KL = Delay 1 (FR1S1.KL, DRDS1) (17)

DRDS1 = Constant

= Dropout Delay at S1 in Time Units

S1P1.KL = IS1P1.KL = ES1P1.KL (18)

The rate at which people retire from the professional sector P1 is called P1R1. As might be expected, that flowrate is determined by the number of people that entered this system 30 or 40 years earlier from high school, the number of people who retire from the Masters and Ph.D. sectors and some appropriate distribution functions regarding the age at which people retire.

Finally, the rate of inflow and outflow of foreigners from the professional sector, namely E1P1 and P1E1 are recognized explicitly in the model and their respective values are assumed to be reasonably constant. An extensive search of available information regarding foreign personnel entering and leaving the United States has revealed that very little good data is now being kept on this subject. If we were to assume relationships which are other than constant values for these flowrates, we would have to greatly expand the model to include the influence of foreign economics, politics, world affairs, cultural patterns, and so forth. For the present time we will make reasonable assumptions regarding these flowrates and turn our attention to more realistic assumptions at a future date.

In a manner substantially similar to the one presented for level 1, the model has been developed for the second, third and fourth level. The flow diagrams are shown in Figures 4, 5 and 6.

SUGGESTED FUTURE EXTENSIONS OF THE MODEL

At the present time the model and the simulation are concerned strictly with the profession of Engineering (not distinguishing between mechanical, electrical, etc. engineers). However, in the future we are looking forward to doing the following:

a. ND4 in the model represents the need for doctorates which is felt in the general population at a given time. This variable must be functionally related to the projected long-range needs of the nation. An extension of the present model is required.

b. Applications to other professions and disciplines each treated individually.

c. Generalization of the model to include several inter-related professions and/or disciplines. (Physical Sciences, Mathematics, and Engineering; The Life Sciences, Behavioral Sciences, and Medicine; The Social Sciences, Law, and Business Administration.)

d. Extension of the generalized model to interrelate all areas of higher learning.

e. To further delineate within all of foregoing model the impact of economic variables (i.e., scholarships, industrial, government and academic salaries, avaiability of money for educational plant...)

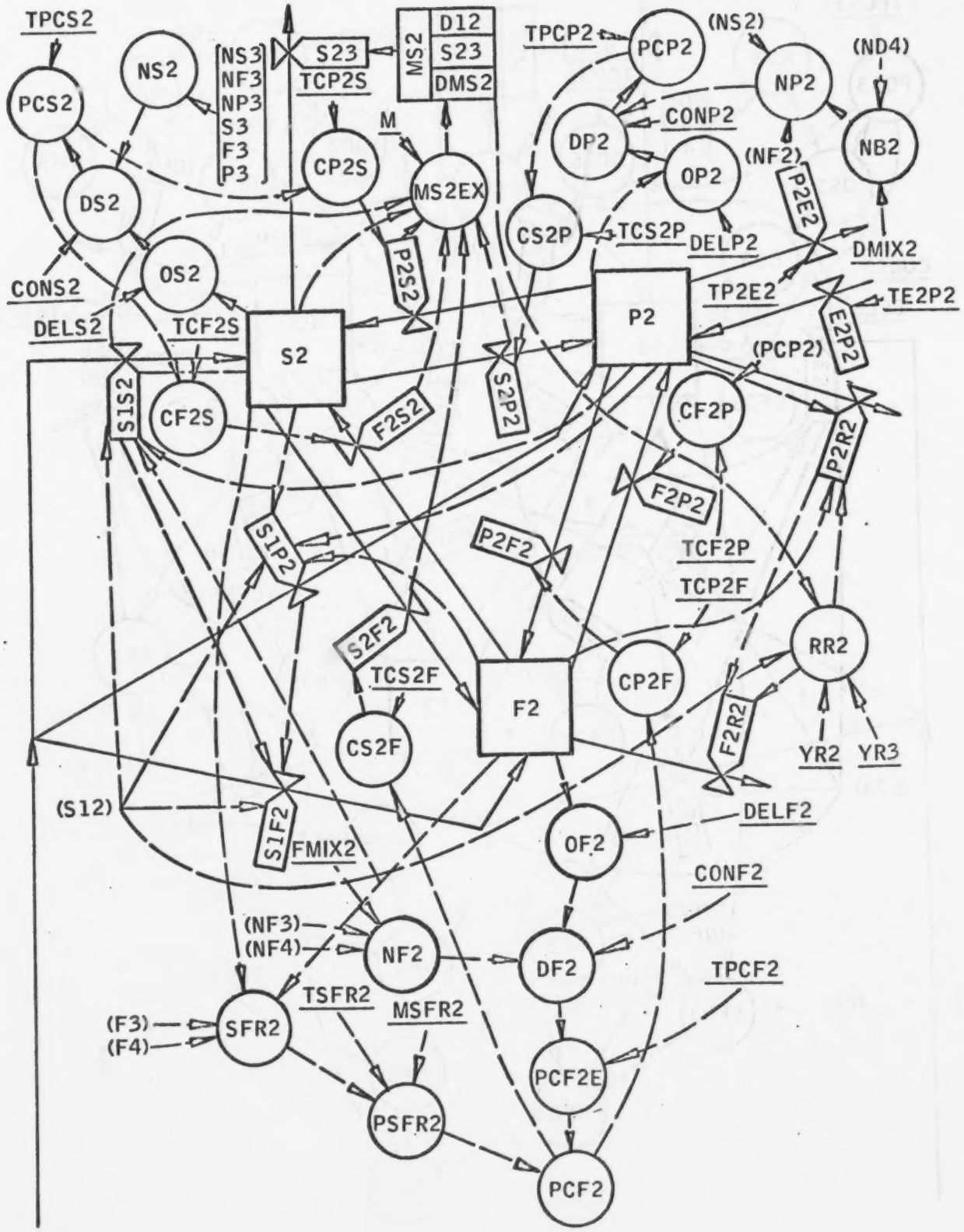


Figure 4

The Location & Flow Paths of People within the Post Baccalaureate Subsector and the Interrelation of Socio-economic Factors which "control" the Population Flows

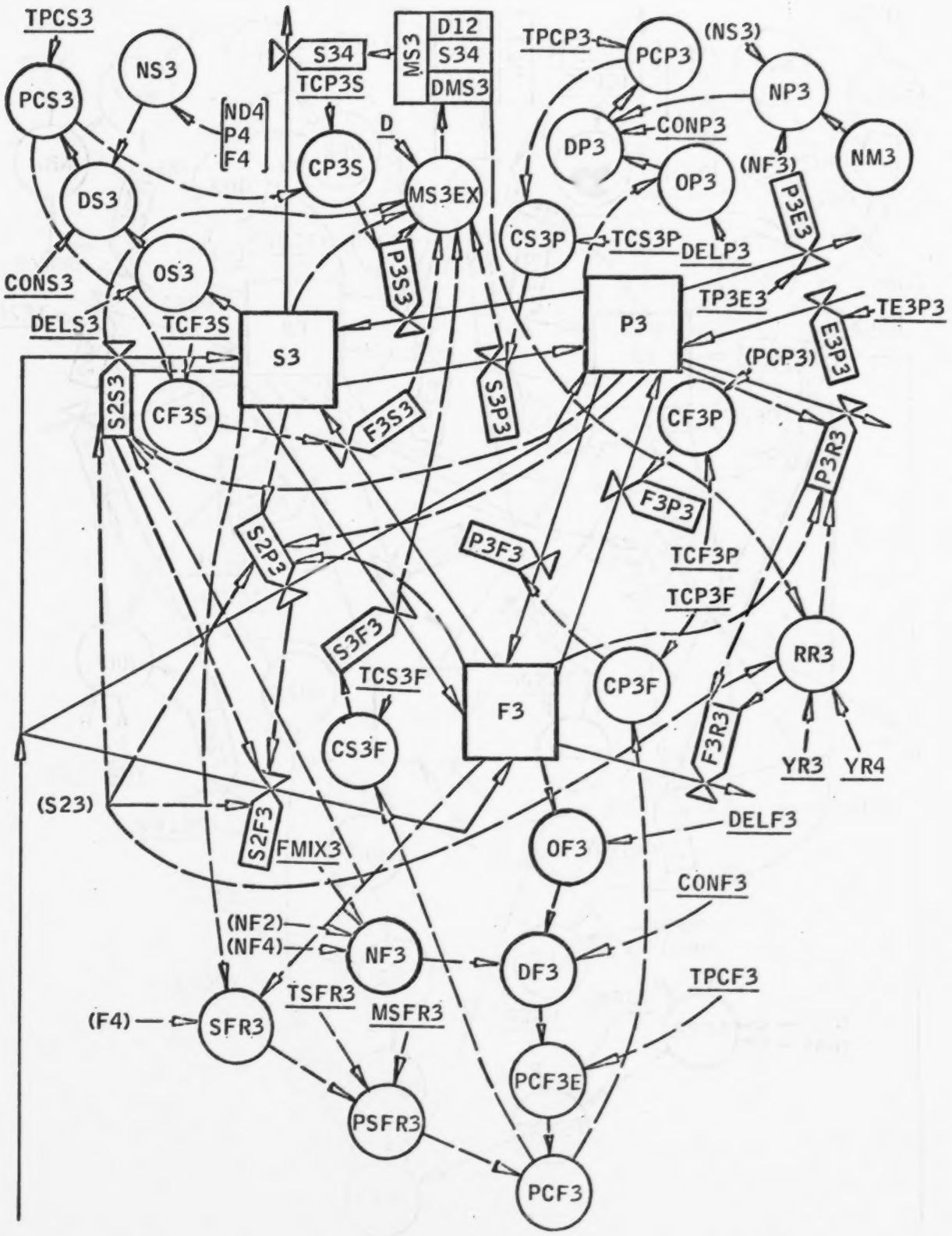


Figure 5

The Location & Flow Paths of People within the Post Masters Subsector and the Interrelation of Socio-economic Factors which "control" the Population Flows

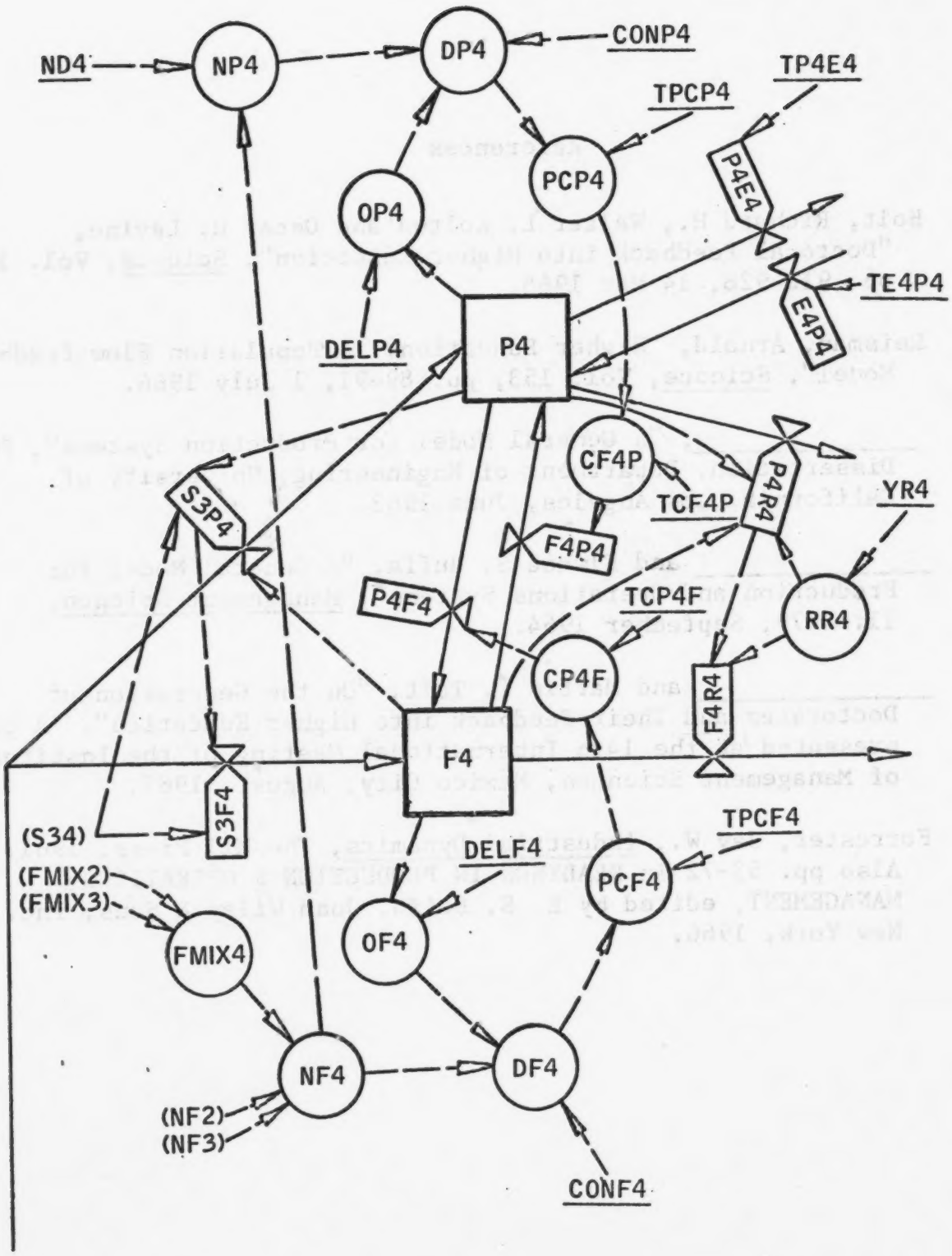


Figure 6

The Location & Flow Paths of People within the Post Doctorate Subsector and the Interrelation of Socio-economic Factors which "control" the Population Flows

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APPENDIX

```
NOTE     PRINT CARDS START AT 40000
NOTE    DEC. 27, 1967
SPEC    DT=1/LENGTH=010/PRTPER=2/PLTPER=2
NOTE     LAYER 1
2L     S1.K=S1.J+(DT)(H1S1.JK+E1S1.JK+P1S1.JK-S1P1.JK-S12.JK+0)
7N     S1=180000/12
2L     P1.K=P1.J+(DT)(E1P1.JK+S1P1.JK-P1E1.JK-P1R1.JK-P1S1.JK+0)
8N     P1=P2+P3+P4
        H1S1.KL=H1S1.JK
6N     H1S1=62000/12
        E1S1.KL=E1S1.JK
6N     E1S1=4600/12
14R    P1S1.KL=P1S1.JK+(CP1S.K)(P1S1.JK)          P1 TO S1
6N     P1S1=0
3.7B   S1D=BOXLIN(7,1)
        OS1.K=S1D*7.K
       S1D*1.K=S1.K
       S1D=BOXLOAD(S1,1)
6N     OS1=S1
10A    NS1.K=NS2.K+NF2.K+NP2.K-F2.K-P2.K-S2.K      NEED FOR S1
6N     NS1=OS1
        DS1.K=NS1.K/OS1.K
6N     DS1=1
        PCS1.K=CLIP(PCS1POS.K,PCS1NEG.K,DS1.K,1)
          PCS1POS.K=1-EXP((-4)((DS1.K-1)(DS1.K-1)(DS1.K-1)))
          PCS1NEG.K=-EXP((-4)(DS1.K)(DS1.K)(DS1.K))
        CP1S.K=(PCS1.K/PCS1ABS.K)(1-EXP((-4)(PCS1ABS.K)-PCS1ABS.K-PCS1ABS
X      .K-PCS1ABS.K))
          PCS1ABS.K=MAX(PCS1.K,-PCS1.K)
6N     S12=20200/12
       DMS1=45  DELAY IN ACT. MATR. FOR BACH. STUDENTS
18R    MS1EX.KL=(SUMS.JK)(1-ADOS1.K)
       SDOS1.K=SUM1(52,BAVS1)
       ADOS1.K=SDOS1.K/52   AV DROP OUT OF S1
44A    BAVS1*1.K=(S1P1.JK)(DT)/S1.K
       BAVS1=BOXLIN(52,1)
       SUMS.KL=BSMS1*52.JK
8R     BSMS1*1.KL=H1S1.JK+E1S1.JK+P1S1.JK
       BSMS1=BOXLIN(52,1)
       BSMS1=BOXLOAD(H1S1+E1S1+P1S1,1)
36N    BAVS1=BOXLOAD(BAVS1*1,1)
       DTPY=12 MONTHS
7A     S1P1.KL=IS1P1.JK+ES1P1.JK
6N     S1P1=8200
       IS1P1.KL=DELAY3(FRIS1.JK,24)
NOTE   PRECEDING SCHOULD BE DELAY 1, NOT 3
6N     IS1P1=0
19R    FRIS1.KL=(PDIS1)(H1S1.JK+E1S1.JK+P1S1.JK+0)
       PDIS1=209/12  (.5-S1)/12
14R    ES1P1.KL=ES1P1.JK+(CS1P.K)(ES1P1.JK)        SOCIAL EXTERNAL
6N     ES1P1=0
       PCP1.K=CLIP(PCP1POS.K,PCP1NEG.K,DP1.K,1)
       PCP1POS.K=1-EXP((-4)((DP1.K-1)(DP1.K-1)(DP1.K-1)))
       PCP1NEG.K=-EXP((-4)(DP1.K-DP1.K-DP1.K))
       PCP1ABS.K=MAX(PCP1.K,-PCP1.K)
       CS1P.K=(PCP1.K/PCP1ABS.K)(1-EXP((-4)-PCP1PWER.K))
        PCP1PWER.K=PCP1ABS.K-PCP1ABS.K-PCP1ABS.K
```

```
        DP1.K=NP1.K/DP1.K
   6N   DP1=0
   7A   NP1.K=NN1.K-NS1.K                                  NEEDS OF P1
   7N   NP1=NN1-NS1
  12A   NN1.K=(DMIX1.K)(ND4.K)
   7A   DMIX1.K=CC1+ATB1.K
  28A   ATB1.K=(AA1)EXP(BLT1.K)
  29A   BLT1.K=(BB1)LOGN(TIME.K)
   C    AA1=0
   C    BB1=0
   C    CC1=17
  12N   NN1=(DMIX1)(ND4)
   6N   DMIX1=20
   C    ND4=650/12
        OP1.K=P1D*7.K
        P1D*1.K=P1.K
        P1D=BOXLIN(7,1)
        P1D=BOXLOAD(P1,1)
        OP1=P1
   6R   P1R1.KL=RR1.JK
   6N   P1R1=0
   9R   RR1.KL=TOTR.JK-RR2.JK-RR3.JK-RR4.JK
   6R   TOTR.KL=TOTR.JK
  19N   TOTR=(.15)(P1+P2+P3+P4)
   6R   E1P1.KL=E1P1.JK                                    FOREIGN TO P1
   6N   E1P1=0
   6R   P1E1.KL=P1E1.JK                                    P1 TO E1
   6N   P1E1=0
   2L   S2.K=S2.J+(DT)(S12.JK+P2S2.JK+F2S2.JK-S23.JK-S2P2.JK-S2F2.JK)
  20N   S2=12400/DTPY
   8A   AP2.K=E2P2.JK+F2P2.JK+S1P2.JK                      AUX. OF P2
   2L   P2.K=P2.J+(DT)(AP2.JK+S2P2.JK-P2E2.JK-P2R2.JK-P2F2.JK-P2S2.JK)
  20N   P2=138000/DTPY
   2L   F2.K=F2.J+(DT)(S1F2.JK+S2F2.JK+P2F2.JK-F2R2.JK-F2P2.JK-F2S2.JK)
  20N   F2=660/DTPY
   8A   AS1S2.K=S2.K+P2.K+F2.K                             AUX. FOR S1S2
  44R   S1S2.KL=(S12.JK)(S2.K)/AS1S2.K
  44R   S1P2.KL=(S12.JK)(P2.K)/AS1S2.K
   8R   S1F2.KL=S12.JK-S1S2.JK-S1P2.JK
  20N   S1F2=1000/DTPY
  14R   F2S2.KL=F2S2.JK+(CF2S.K)(F2S2.JK)
   6N   F2S2=0
        PCS2.K=CLIP(PCS2POS.K,PCS2NEG.K,DS2.K,1)
        PCS2POS.K=1-EXP((-4)((DS2.K-1)(DS2.K-1)(DS2.K-1)))
        PCS2NEG.K=-EXP((-4)(DS2.K-DS2.K-DS2.K))
        PCS2ABS.K=MAX(PCS2.K,-PCS2.K)
        CF2S.K=(PCS2.K/PCS2ABS.K)(1-EXP((-4)(PCS2PWER.K)))
         PCS2PWER.K=PCS2ABS.K-PCS2ABS.K-PCS2ABS.K
  10A   NS2.K=NS3.K+NF3.K+NP3.K-F3.K-P3.K-S3.K             NEEDS OF S2
   6N   NS2=OS2
        DS2.K=NS2.K/OS2.K
   6A   OS2.K=S2D*7.K                                      6 MONTH DELAY
        S2D*1.K=S2.K
        S2D=BOXLIN(7,1)
        S2D=BOXLOAD(S2,1)
   6N   OS2=S2
```

```
        P2S2.KL=P2S2.JK+(CP2S.K)(P2S2.JK)
            P2S2=0
        CP2S.K=(PCS2.K/PCS2ABS.K)(1-EXP((-4)(PCS2PWER.K)))
14R     S2P2.KL=S2P2.JK+(CS2P.K)(S2P2.JK)
20N     S2P2=6500/DTPY
        CS2P.K=(PCP2.K/PCP2ABS.K)(1-EXP(-4-PCP2PWER.K))
        CF2P.K=CS2P.K
14R     F2P2.KL=F2P2.JK+(CF2P.K)(F2P2.JK)
6N      F2P2=0
        PCP2.K=CLIP(PCP2POS.K,PCP2NEG.K,DP2.K,1)
        PCP2POS.K=1-EXP((-4)((DP2.K-1)(DP2.K-1)(DP2.K-1)))
        PCP2NEG.K=-EXP(-4-(DP2.K-DP2.K-DP2.K))
        PCP2ABS.K=MAX(PCP2.K,-PCP2.K)
         PCP2PWER.K=PCP2ABS.K-PCP2ABS.K-PCP2ABS.K
8A      NP2.K=NB2.K-NF2.K-NS2.K
6N      NP2=OP2
12A     NB2.K=(DMIX2.K)(ND4.K)
7A      DMIX2.K=CC2+ATB.K
28A     ATB.K=(AA2)EXP(BLT.K)
29A     BLT.K=(BB2)LOGN(TIME.K)
8N      NB2=NP2+NF2+NS2
6N      DMIX2=76.3/5.00
C       AA2=0
C       BB2=0
C       CC2=13
        DP2.K=NP2.K/OP2.K
6A      OP2.K=BOXP2*13.K
6A      BOXP2*1.K=P2.K
37B     BOXP2=BOXLIN(13,1)
        BOXP2=BOXLOAD(P2,1)
14R     S2F2.KL=S2F2.JK+(CS2F.K)(S2F2.JK)
6N      S2F2=0
        CS2F.K=(PCF2.K/PCF2ABS.K)(1-EXP(-4-PCF2PWER.K))
         PCF2PWER.K=PCF2ABS.K-PCF2ABS.K-PCF2ABS.K
        PCF2ABS.K=MAX(PCF2.K,-PCF2.K)
7A      PCF2.K=PCF2E.K+PSFR2.K
7N      PCF2=PCF2E+PSFR2
        PSFR2.K=CLIP(PSFR2POS.K,PSFR2NEG.K,SFR2.K,MSFR2.K)
        PSFR2POS.K=1-EXP(-4-SFR2POWERABS.K)
         SFR2PPER.K=(SFR2.K-MSFR2)(SFR2.K-MSFR2.K)(SFR2.K-MSFR2)
        SFR2POWERABS.K=MAX(SFR2PPER.K,-SFR2PPER.K)
        PSFR2NEG.K=-EXP(-4-SFR2.K-SFR2.K-SFR2.K)
C       MSFR2=20     AVER. OR DESIRED MASTERS LEVEL START OF SFR2
8A      FF.K=F2.K+F3.K+F4.K
20A     SFR2.K=S2.K/FF.K
8N      FF=F2+F3+F4
20N     SFR2=S2/FF
        PCF2E.K=CLIP(PCF2EPOS.K,PCF2ENEG.K,DF2.K,1)
        PCF2EPOS.K=1-EXP(-4-((DF2.K-1)(DF2.K-1)(DF2.K-1)))
        PCF2ENEG.K=-EXP(-4-(DF2.K-DF2.K-DF2.K))
        DF2.K=NF2.K-OF2.K
            DF2=1
19A     NF2.K=(FMIX2.K)(NF4.K+NF3.K+NF2.K+0)        NEEDS OF F2
6N      NF2=OF2
7A      FMIX2.K=FF2+DTE.K
28A     DTE.K=(DD2)EXP(ELT.K)
29A     ELT.K=(EE2)LOGN(TIME.K)
```

```
C     DD2=0
C     EE2=0
C     FF2=.1
6A    OF2.K=BOXF2*5.K                                    4 MONTH DELAY
6A    BOXF2*1.K=F2.K
      BOXF2=BOXLIN(5,1)
      BOXF2=BOXLOAD(F2,1)
6N    OF2=F2
14R   P2F2.KL=P2F2.JK+(CP2F.K)(P2F2.JK)
6N    P2F2=0
      CP2F.K=(PCF2.K-PCF2ABS.K)(1-EXP(-4-PCF2PWER.K))
50R   P2R2.KL=(RR2.JK)(P2.K)/(P2.K+F2.K)
20N   P2R2=2444/DTPY
      RR2.KL=DELAY6(BXS12*516,24)
      BXS12=BOXLIN(516,1)
      BXS12=BOXLOAD(S12,1)
6A    BXS12*1.K=S12.JK
      F2R2.KL=RR2.JK-P2R2.JK
20N   F2R2=156/DTPY
      S23.KL=DELAY3(MS2EX.JK,6)
NOTE   SHOULD HAVE BEEN DELAY 1, NOT 3
20N   S23=4444/DTPY
18R   MS2EX.KL=(SUMA.JK)(1-ADOS2.K)
      SUMA.K=BSMS2*35.K
8R    BSMS2*1.KL=F2S2.JK+P2S2.JK+S1S2.JK
37B   BSMS2=BOXLIN(35,1)
53A   ADOS2.K=SUM1(35,BAVS2.K)/35
22A   BAVS2*1.K=(1/S2.K)((S2P2.K)(DT)+(S2F2.K)(DT))
37B   BAVS2=BOXLIN(35,1)
      BSMS2=BOXLOAD(F2S2+P2S2+S1S2,1)
      BAVS2=BOXLOAD(BAVS2*1,1)
6R    E2P2.KL=E2P2.JK
20N   E2P2=3047/DTPY
      P2E2.KL=P2E2.JK
      P2E2=0

NOTE   LAYER 3

2L    S3.K=S3.J+(DT)(S23.JK+P3S3.JK+F3S3.JK-S34.JK-S3P3.JK-S3F3.JK)
20N   S3=2921/DTPY
8A    AP3.K=-P3R3.JK-P3F3.JK-P3S3.JK                     AUX. OF P3
2L    P3.K=P3.J+(DT)(E3P3.JK+F3P3.JK+S2P3.JK+S3P3.JK-P3E3.JK+AP3.JK)
20N   P3=33700/DTPY
2L    F3.K=F3.J+(DT)(S2F3.JK+S3F3.JK+P3F3.JK-F3R3.JK-F3P3.JK-F3R3.JK)
20N   F3=2640/DTPY
8A    AS2S3.K=S3.K+P3.K+F3.K
44R   S2S3.KL=(S23.JK)(S3.K)/AS2S3.K
44R   S2P3.KL=(S23.JK)(P3.K)/AS2S3.K
8R    S2F3.KL=S23.JK-S2S3.JK-S2P3.JK                     IS S2S3 CORRECT
14R   F3S3.KL=F3S3.JK+(CF3S.K)(F3S3.JK)
      CP3S.K=(PCS3.K/PCS3ABS.K)(1-EXP(-4-PCS3PWER.K))
      PCS3.K=CLIP(PCS3POS.K,PCS3NEG.K,DS3.K,1)
      PCS3POS.K=1-EXP(-4-((DS3.K-1)(DS3.K-1)(DS3.K-1)))
      PCS3NEG.K=-EXP(-4-(DS3.K-DS3.K-DS3.K))
       PCS3PWER.K=PCS3ABS.K-PCS3ABS.K-PCS3ABS.K
      PCS3ABS.K=MAX(PCS3.K,-PCS3.K)
```

```
        DS3.K=NS3.K/OS3.K
 8A     NS3.K=ND4.K-P4.K-F4.K
 6N     NS3=OS3
        OS3.K=S3D*7.K  6 MO DELAY
 6A     S3D*1.K=S1.K
 37B    S3D=BOXLIN(7,1)
        S3D=BOXLOAD(S3,1)
        OS3=S3
 NOTE   DELS3=48  WHATS IT FOR
 14R    P3S3.KL=P3S3.JK+(CP3S.K)(P3S3.JK)
 6N     P3S3=0
        CF3S.K=CP3S.K  SAME FOR NOW
 14R    S3P3.KL=S3P3.JK+(CS3P.K)(S3P3.JK)
 6N     S3P3=0
        CS3P.K=(PCP3.K/PCP3ABS.K)(1-EXP(-4-PCP3PWER.K))
        PCP3.K=CLIP(PCP3POS.K,PCP3NEG.K,DP3.K,1)
        PCP3POS.K=1-EXP(-4-((DP3.K-1)(DP3.K-1)(DP3.K-1)))
        PCP3NEG.K=-EXP(-4-(DP3.K-DP3.K-DP3.K))
         PCP3PWER.K=PCP3ABS.K-PCP3ABS.K-PCP3ABS.K
        PCP3ABS.K=MAX(PCP3.K,-PCP3.K)
        DP3.K=NP3.K/DP3.K
        OP3.K=BOXP3*7.K
        BOXP3*1.K=P3.K
 37B    BOXP3=BOXLIN(7,1)
 6N     OP3=P3
 36N    BOXP3=BOXLOAD(P3,1)
 8A     NP3.K=NM3.K-NF3.K-NS3.K
 6N     NP3=OP3
 12A    NM3.K=(DMIX3.K)(ND4.K)
 7A     DMIX3.K=CC3+ATB3.K
 28A    ATB3.K=(AA3)EXP(BLT3.K)
 29A    BLT3.K=(BB3)LOGN(TIME.K)
 8N     NM3=NP3+NF3+NS3
 6N     DMIX3=18.815
 C      AA3=1
 C      BB3=1
 C      CC3=20.0/6.0
 14R    F3P3.KL=F3P3.JK+(CF3P.K)(F3P3.JK)
 6N     F3P3=0
        CF3P.K=CS3P.K  SAME FOR NOW
 14R    S3F3.KL=S3F3.JK+(CS3F.K)(S3F3.JK)
 6N     S3F3=0
        CS3F.K=(PCF3.K/PCF3ABS.K)(1-EXP(-4-PCF3PWER.K))
 7A     PCF3.K=PCF3E.K+PSFR3.K
 7N     PCF3=PCF3E+PSFR3
        PCF3ABS.K=MAX(PCF3.K,-PCF3.K)
         PCF3PWER.K=PCF3ABS.K-PCF3ABS.K-PCF3ABS.K
        PSFR3.K=CLIP(PSFR3POS.K,PSFR3NEG.K,SFR3.K,1)
        PSFR3POS.K=1-EXP(-4-(SFR3.K-1)(SFR3.K-1)(SFR3.K-1))
        PSFR3NEG.K=-EXP(-4-SFR3.K-SFR3.K-SFR3.K)
 26A    SFR3.K=(S3.K+0+0)/(F2.K+F3.K+F4.K)
 26N    SFR3=(S3+0+0)/(F2+F3+F4)
        DF3.K=NF3.K/DF3.K
        PCF3E.K=CLIP(PCF3EPOS.K,PCF3ENEG.K,DF3.K,1)
        PCF3EPOS.K=1-EXP(-4-(DF3.K-1)(DF3.K-1)(DF3.K-1))
        PCF3ENEG.K=-EXP(-4-DF3.K-DF3.K-DF3.K)
        NF3.K=(FMIX3.K)(NF4.K+NF3.K+NF2.K)
```

```
            FMIX3.K=FF3+DTE3.K
  28A       DTE3.K=(DD3)EXP(ELT3.K)
  29A       ELT3.K=(EE3)LOGN(TIME.K)
  6N        NF3=OF3
  C         DD3=1
  C         EE3=0
  C         FF3=0.3
  6A        OF3.K=BOXF3*7.K
  6A        BOXF3*1.K=F3.K
  37B       BOXF3=BOXLIN(7,1)
  6N        OF3=F3
  36N       BOXF3=BOXLOAD(F3,1)
  39R       S34.KL=DELAY3(MS3EX.JK,12)
  NOTE        SHOULD BE DELAY 1, NOT 3
  20N       S34=600/DTPY
  18R       MS3EX.KL=(SUMB.JK)(1-ADOS3.K)
  53A       AUXAD.K=SUM1(62,BAVS3.K)
  20A       ADOS3.K=AUXAD.K/62
  22A       BAVS3*1.K=(1/S3.K)((S3P3.K)(DT)+(S3F3.K)(DT))
  37B       BAVS3=BOXLIN(62,1)
            BAVS3=BOXLOAD(BAVS3*1,1)
  6A        SUMB.K=BSMS3*52.K
  7A        BSMS3*1.K=P3S3.JK+S2S3.JK
  37B       BSMS3=BOXLIN(52,1)
            BSMS3=BOXLOAD(P3S3+S2S3,1)
  50R       P3R3.KL=(RR3.JK)(P3.K)/(P3.K+F3.K)
  6N        P3R3=0
  39R       RR3.KL=DELAY3(RR3A.JK,DRET3)
  39R       RR3A.KL=DELAY3(UDRR3.JK,DRET3)
  44N       DRET3=(DYR3)(DTPY)/2
  C         DYR3=(2.0)(DTPY)
  6A        UDRR3.K=BRR3*31.K
  6A        BRR3*1.K=S23.JK
  37B       BRR3=BOXLIN(31,SFTR3)
            BRR3=BOXLOAD(S23,1)
  44N       SFTR3=(YR3)(DTPY)/30
  7N        YR3=YR3T-2
  C         YR3T=38          TOTAL YEARS TO RETIREMENT AFTER MASTERS DEG
  7R        F3R3.KL=RR3.JK+P3R3.JK                    (+ OR - )
  12N       E3P3=(.1)(S23)
  6N        E3P3.KL=E3P3.JK
  6N        P3E3.KL=P3E3.JK
            P3E3=0
  14R       P3F3.KL=P3F3.JK+(CP3F.K)(P3F3.JK)
  7N        P3F3=PCF3E+PSFR3
            CP3F.K=(PCF3.K/PCF3ABS.K)(1-EXP(-4-PCF3PWER.K))

  NOTE              LAYER 4
  2L        P4.K=P4.J+(DT)(S3P4.JK+F4P4.JK+E4P4.JK-P4F4.JK-P4E4.JK-P4R4.JK)
  12N       P4=(PCTP4)(D4I)
            PCTP4=.94   ( DOC. ARE PROF.
  C         D4I=9000/DTPY          DOCTORATE HOLDERS INITIALLY
  2L        F4.K=F4.J+(DT)(S3F4.JK+P4F4.JK-F4P4.JK-F4R4.JK+0+0)
  20N       F4=2720/DTPY
            S3F4.K=S34.JK-S3P4.JK
  50R       S3P4.KL=(S34.JK)(P4.K)/(P4.K+F4.K)
```

```
14R   F4P4.KL=F4P4.JK+(CF4P.K)(F4P4.JK)
      CF4P.K=(PCP4.K/PCP4ABS.K)(1-EXP(4-PCP4PWER.K))
      DP4.K=NP4.K/DP4.K
      PCP4.K=CLIP(PCP4POS.K,PCP4NEG.K,DP4.K,1)
      PCP4POS.K=1-EXP(-4-(DP4.K-1)(DP4.K-1)(DP4.K-1))
      PCP4NEG.K=-EXP(-4-DP4.K-DP4.K-DP4.K)
       PCP4PWER.K=PCP4ABS.K-PCP4ABS.K-PCP4ABS.K
      PCP4ABS.K=MAX(PCP4.K,-PCP4.K)
6A    DP4.K=BOXP4*13.K
6A    BOXP4*1.K=P4.K
       BOXP4=BOXLIN(13,1)
      BOXP4=BOXLOAD(P4,1)
      DF4.K=NF4.K/DF4.K
      NP4.K=ND4.K-NF4.K
      ND4.K=D4.K
      D4.K=D4.J
      D4=F4
NOTE    ******** D4 VALUE =FS USED , NOT CORRECT****
6A    DF4.K=BOXF4*7.K     6 MO DELAY
6A    BOXF4*1.K=F4.K
37B   BOXF4=BOXLIN(7,1)
36N   BOXF4=BOXLOAD(F4,1)
6N    DF4=F4
19A   NF4.K=(FMIX4.K)(NF4.K+NF3.K+NF2.K+0)
6N    NF4=DF4
8A    FMIX4.K=1-FMIX3.K-FMIX2.K
14R   P4F4.KL=P4F4.JK+(CP4F.K)(P4F4.JK)
6N    P4F4=0
      PCF4.K=CLIP(PCF4POS.K,PCF4NEG.K,DF4.K,1)
      PCF4POS.K=1-EXP(-4-(DF4.K-1)(DF4.K-1)(DF4.K-1))
      PCF4NEG.K=-EXP(-4-DF4.K-DF4.K-DF4.K)
      PCF4ABS.K=MAX(PCF4.K,-PCF4.K)
       PCF4PWER.K=PCF4ABS.K-PCF4ABS.K-PCF4ABS.K

      CP4F.K=(PCF4.K/PCF4ABS.K)(1-EXP(-4-PCF4PWER.K))
NOTE  P4R4.KL=(RR4.JK)(P4.K)/(P4.K+F4.K)
NOTE   P4R4 CHANGED BECAUSE OF SIMUTANEOUS EQ.
      P4R4.KL=RR4.JK-P4.K
10N   P4R4=S3P4+E4P4-P4E4-P4R4+F4R4+0
7R    F4R4.KL=RR4.JK-P4R4.JK
      F4R4=0
NOTE   ABOVE IS INCORRECT, CHANGED TO RID SIMULTAN EQ.
      RR4.KL=DELAY6(BRR4*25,24)
6A    BRR4*1.K=S34.JK
37B   BRR4=BOXLIN(21,1)
      BRR4=BOXLOAD(S34,1)
12N   RR4=(.15)(9000)
6R    P4E4.KL=P4E4.JK
6N    P4E4=0
6R    E4P4.KL=E4P4.JK
6N    E4P4=0
NOTE     END OF DYNAMO DECK
NOTE   PRINT  CARDS
PRINT   1)S1,S2,S3/2)P1,P2,P3,P4/3)F2,F3,F4/4)S12,S1S2,S1P2,S1F2/5)S23,S
X     2S3,S2P3,S2F3/6)S34,*,S3P4,S3F4/7)S1P1,S2P2,S3P3,*/8)P1S1,P2S2,P3S
X     3,*
PLOT   S1=S,P1=P/S2P2=B,F2=C/S3=D,P3=E,F3=F/P4=G,F4=H
```